Control of immature stages of the flea *Ctenocephalides felis* (Bouché) in carpets exposed to cats treated with imidacloprid

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ABSTRACT

Fleas cause allergic dermatitis in cats and dogs and therefore warrant control. It has been demonstrated previously that there is marked inhibition of the development of the immature stages of the cat flea *Ctenocephalides felis* on fleece blankets exposed to cats treated with imidacloprid. This study reports on the efficacy of imidacloprid in suppressing adult flea emergence in carpet exposed to treated cats. Circular discs of carpet pre-seeded with flea eggs and larvae were exposed to 6 untreated control and 6 topically treated (imidacloprid 10 % m/v) cats 1 to 2 days after treatment and subsequently fortnightly for 6 weeks. Exposure times on alternate days were either 1 or 6 hours. Adult flea yield from carpets was determined 35 days after exposure. Differences between flea yield on control carpets and those exposed for 1 hour were significant only for days +1 and +14. For the 6-hour exposure, differences were significant at all times except on Day +43. The ability of imidacloprid to suppress the yield of adult fleas on carpets (6-hour exposure) steadily declined from 82 % (Day +2) to 12 % (Day +43). For the 1-hour exposure it varied inconsistently between 0 and 83 % over the 6-week study period.

Key words: flea control, flea larvae, imidacloprid, cats, environment.

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INTRODUCTION

Adult cat fleas, *Ctenocephalides felis* (Bouché) are obligate ectoparasites of various mammalian species[3]. They attack humans and companion animals, and also cause allergic dermatitis in cats and dogs.

To effectively control fleas, a sound knowledge of their developmental biology and ecology is required. Recent advances in our understanding of flea biology and the formulation of control strategies have increasingly emphasised the advisability of an environmental flea control programme to augment flea elimination from the host[3]. The rationale is that eggs, larvae, pupae and newly emerged adults provide a continual reservoir for re-infection. This reservoir can be depleted through the use of potent long-acting insecticides applied at regular intervals[5], chemical treatment of the hosts combined with mechanical and chemical environmental control[2], and, more recently, on-host products with an adulticidal plus environmental (sterilising eggs) action[3]. The perceived effectiveness of an on-host flea product may be markedly influenced by the type of simultaneous environmental flea control that is being conducted[3].

Imidacloprid (Advantage®; Bayer Animal Health) belongs to a new class of compounds that binds to the nicotinergic acetylcholine receptor of insects[8]. Besides a very high adulticidal flea efficacy on dogs and cats[1,5] it also affects the development of flea larvae[4,6]. The larvicidal efficacy of imidacloprid was tested under controlled laboratory conditions by exposing fleece blanket material to treated cats and monitoring adult flea emergence from eggs placed on this material[6]. Within a domestic situation, however, cats may habitually rest on various substrates in the home, including carpets. Controlling the immature stages of fleas in carpets is especially difficult to achieve because treatment fails to make contact with larvae where they develop at the base of carpet fibres[3,10]. The objectives of this study were to determine the extent to which Advantage® (imidacloprid 10 % m/v) can suppress adult flea emergence when carpets, pre-infested with eggs and larvae, are exposed to treated cats for varying times and at increasing periods after treatment.

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MATERIALS AND METHODS

Study design

Twelve cats were allocated to the control (n = 6) and treatment groups (n = 6) on the basis of hair length. Each group consisted of 3 long-haired and 3 short-haired cats and the groups were also balanced with respect to body mass. The treatment group received imidacloprid on Day 0 and different sets of carpets, pre-infested with flea eggs and larvae, were exposed on alternate days (1/2, 14/15, 28/29, 42/43) to treated and control cats for 1 or 6 hours, respectively. The closed-pile carpet used (Bolero level-loop carpet manufactured from Declon Nylon 6, pile height 4 mm) is a type often installed in medium-priced dwellings in South Africa, and has been confirmed as a suitable substrate for flea development. Circular disks (27 cm diameter) of carpet were cut to fit into the base of circular plastic bowls. One hour before exposure of carpets to cats, 100 eggs, 70 L_1/L_2 and 30 L_3 larvae, originating from donor cats, were seeded onto the carpets together with 8.5 g of larval feeding medium consisting of 5.0 g sand, 1.5 g bone meal and 2.0 g dried bovine blood meal. During exposure each cat was confined to a cage just large enough to house the circular basin so that the cat was forced to remain in direct contact with the carpet bedding inside the basin. Most cats slept peacefully on the carpets for the duration of the exposure period.

Assessment

Following exposure of the circular carpet cuttings to cats inside the plastic bowls, the lower sections of the bowls were cut off without disturbing the carpets or developmental stages of fleas. Each of the bottom sections was subsequently transferred directly to a similar but slightly larger bowl in which it was supported in an elevated position on plastic pillars. A glycerol/water mixture (42 % glycerol by weight) was poured into the larger bowl and the top of the bowl then covered with a thin plastic covering (GLAD® wrap). The RH inside the container was about 85 %. The plastic containers were kept at 25 °C and a photoperiod of

12Light:12Dark. After 35 days the adult fleas floating in the glycerol/water mixture were counted. Vacuum suction was also used to extract all fleas from carpets.

Husbandry

Animals were housed in climate-controlled animal rooms that comply with local animal welfare standards. Control and treated cats were kept in separate rooms and cats were identified by alphanumeric numbers using an electronic transponder. For each exposure, cats were assigned to the same labelled cage. Exposure of control and treated cats took place in separate rooms. Control cats were always handled before treated cats and strict precautions were taken to prevent the transfer of chemicals between rooms or cages. Room temperature was maintained at a constant 24 ± 2 °C and RH at 50 ± 10 %.

Treatment

Cats were treated with a 10 % topical ('spot-on') formulation of imidacloprid (Advantage®, Bayer) at the dose rate prescribed on the label, *i.e.* 0.40 mℓ for cats weighing less than 4.0 kg, and 0.80 mℓ for cats 4.0 kg and more. The product was applied dermally, just below the base of the skull. Fur was parted and the product deposited directly onto the skin. The cat was then restrained for 1 minute to permit initial product spread.

Analysis

The number of adult fleas (dead or alive) on the day of examination, *i.e.,* 35 days after exposure of the carpet discs to the cats, was used to calculate percentage efficacy according to the following formula:

$$\text{Efficiency (\%)} = \frac{C-T}{C} \times \frac{100}{1},$$

where C = mean number of fleas recovered from the carpet discs exposed to untreated cats, and T = mean number of fleas recovered from the carpet discs exposed to treated cats.

The yield of adult fleas from carpets exposed to control and treated cats for each time interval were compared by an analysis of variance with a time effect. To compare the yield of adult fleas from carpets exposed for 1 and 6 hours to the treated cats respectively, for the different time points, analysis of variance with the cat and exposure time as main effects were conducted. A significance level of $P < 0.05$ was used throughout.

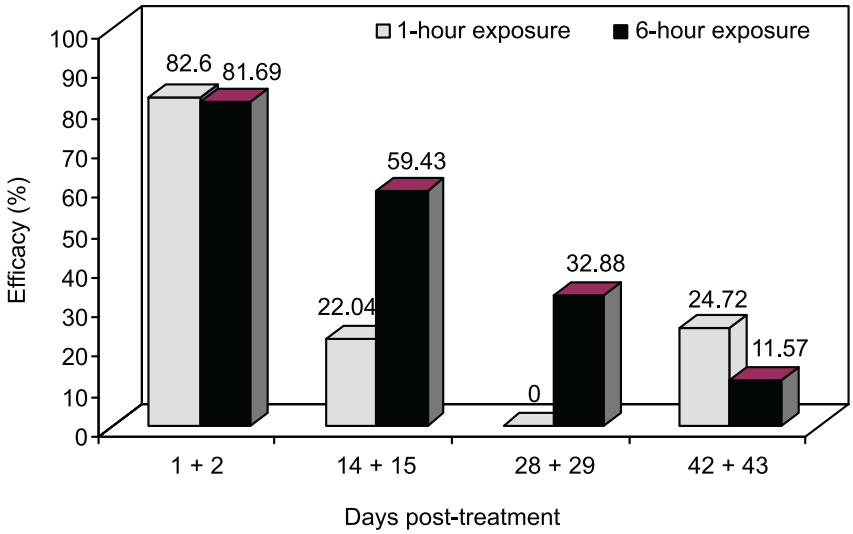

Fig. 1: **Efficacy** (%) **of carpets exposed to the Advantage-treated cats for 1 and 6 hours, in suppressing development of fleas up to the adult stage.**

RESULTS

The yields of adult fleas from carpets exposed to control and treated cats are summarised in Table 1. The data obtained from some of the samples had to be disregarded owing to disturbance (carpets overturned) during the period of exposure. In the control group the mean number of adult fleas recovered from the carpets varied between 29.67 and 68.60 for the 1- and 6-hour exposures. The mean number of adult fleas recovered from carpets exposed to treated cats for 1 hour varied between 9.33 and 71.00, and for carpets exposed to treated cats for 6 hours it varied between 9.00 and 31.83 (Table 1). Differences between the yield of fleas from carpets exposed to control and treated cats only differed significantly ($P < 0.05$) for the first two time intervals (*i.e.* Days +1 and +14). In the case of carpets exposed to control cats and those exposed to treated cats for 6 hours, the results of all the time intervals, except Day +43, differed significantly. Comparisons between the yield of fleas from carpets exposed for 1 and 6 hours respectively showed significant differences ($P < 0.05$) on exposure Days +14/+15 and +28/+29. The efficacy of the imidacloprid to suppress the yield of adult fleas (Days +1/+2) on carpets exposed to treated cats was 82.60 % and 81.69 % for the 1- and 6-hour exposures. Efficacy for the 6-hour exposures showed a consistent and gradual decrease to 11.57 % on Day +43 (Fig. 1). For the 1-hour exposures efficacy varied inconsistently between 0 % (Day +28) and 24.72 % (Day +42).

Table 1: **Mean** (range) **of adult fleas emerged from carpets exposed to control or treated cats, for periods of 1 and 6 hours** (on consecutive days) **at different times post-treatment. Percentage efficacy in suppressing development up to the adult stage is also indicated. Missing data resulted because of carpets disturbed by cats or excessive soiling during exposure.**

Days post-treatment	Adult fleas emerged		% Efficacy
	Control carpets $\bar{x}$ (range)	Treated carpets $\bar{x}$ (range)	
+1 (1 h)	53.83 (36–77)	9.33 (3–17)	82.60
+2 (6 h)	49.17 (31–72)	9.00 (3–17)	81.69
+14 (1 h)	[a]62.00 (48–82)	48.33 (41–56)	22.04
+ 15 (6 h)	58.33 (49–74)	23.67 (14–40)	59.43
+28 (1 h)	[a]68.60 (63–74)	71.00 (61–82)	0
+29 (6 h)	[a]44.20 (26–58)	29.67 (23–45)	32.88
+42 (1 h)	29.67 (17–45)	22.33 (12–32)	24.72
+43 (6 h)	[b]36.00 (23–45)	31.83 (19–53)	11.57

[a]One value left out.
[b]Two values left out.

DISCUSSION AND CONCLUSIONS

The experimental design attempted to simulate a normal household in which eggs and larvae are present for some time after treatment. The yield of adult fleas from the carpets exposed to control cats was substantially lower compared to that normally achieved (>80 %) when rearing fleas in sand.

Various factors such as cannibalism, depletion of larval rearing media, abrasion or volatile chemicals remaining from carpet manufacture[3,7] may have contributed to the results obtained in this study. They may, however, reflect potential adult flea yield in a normal household. A lower than expected adult flea yield from fleece blankets seeded with flea eggs and larval rearing medium has also been reported previously[6].

The greatest suppression (>80 %) in adult flea yield was achieved soon after treatment. The adult flea yield from carpets exposed (Days +1/+2) to imidacloprid-treated cats for 1 and 6 hours respectively was very similar and most probably reflects an extensive transfer of insecticide from treated cats to carpets. Efficacy in suppression of adult flea emergence from the carpets exposed to treated cats for subsequent time points are, however, related to time of exposure. Results obtained on adult flea yield from the carpets exposed to treated cats for 1 hour, 2, 4 and 6 weeks after treatment was highly variable. Conversely, carpets exposed to treated cats for 6 hours showed a steady decline in efficacy to depress adult flea yields. This indicated a higher rate of insecticide transfer from the cats than for the 1-hour exposure. Results from a previous study[6], where fleece blankets were exposed to imidacloprid-treated cats for 6 hours per day on 5 consecutive days, indicated a 74 % reduction in adult flea yield 4 weeks after treatment, compared to 33 % obtained in this study (6-hour exposure). It can be inferred that there will be a marked suppression of adult flea emergence in carpets under natural conditions where the duration of exposure to treated cats at a favourite resting place will be considerably longer than the 6 hours used in the test system. The combined findings imply that imidacloprid has a larvicidal effect in the direct surroundings (resting and sleeping areas) of treated animals[4,6]. The exact manner in which imidacloprid is transferred to these surroundings is still unresolved. In a study in which skin debris from imidacloprid-treated dogs was incubated with *C. felis* larvae, >99 % failed to pupate[4].

Direct transfer of active ingredient onto the substrates used by the treated animals can also be potentially very important. After treatment, large reservoirs of fleas in various stages of development usually remain, especially where the pet rests or sleeps[9]. Depending on prevailing climatic conditions, adult fleas may emerge from these surroundings over a period of several weeks[3]. Prolonged exposure of resting and sleeping areas to imidacloprid-treated cats will, however, significantly suppress development of fleas. Those fleas that do develop and infest the cat will most likely be killed by the insecticide. Imidacloprid has considerable potency against adult fleas on cats and affords a high level of residual activity for 4–5 weeks[5]. The environmental effect of imidacloprid combined with a high on-host adulticidal efficacy will greatly reduce or even eliminate re-infestation of cats in a household environment, and therefore diminish the clinical manifestation of flea allergic dermatitis.

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